REMARKS

Claims 1-2 were rejected as anticipated by HOULIHAN et al. 6,258,673. Reconsideration and withdrawal of the rejection are respectfully requested.

Claims 1-2 include the steps of injecting fluorine into a region of the substrate where the gate insulating film is to be thick ("other than a region of the semiconductor substrate where a thinnest gate insulating film is to be formed"), oxidizing the parts injected with fluorine, and nitriding the exposed surface of the oxide to form oxynitride or a nitride film on the exposed surface of the oxide. These steps are illustrated, by way of example, in Figures 3a-3e. The result of the nitriding step is shown in Figure 3e.

HOULIHAN et al. disclose a process similar to the process shown in Figures 3a-d, but do not disclose the nitriding step at the end of claim 1. The process in HOULIHAN et al. suggests implanting nitrogen ions, which retards the growth of oxide in an unoxidized silicon, or implanting one of fluorine, chlorine and oxygen ions, which promote the growth of oxide in an unoxidized silicon, to form silicon oxide layers of different thicknesses (column 2, lines 38-42, column 3, lines 9-12).

HOULIHAN et al. also suggest that both growth retarding and growth promoting ions can be implanted in the same location (column 3, lines 13-21). That is, nitrogen ions and one of the

growth promoting ions could be used to tailor the thickness depending on the number and sequence of mask applications and ion implants. As an example of this, HOULIHAN et al. suggest that both nitrogen ions and oxygen ions could be implanted to produce SiON. The Official Action relies on this latter example for the nitriding step in claim 1.

However, this example does not disclose injecting fluorine into a region of the substrate where the gate insulating film is to be thick, oxidizing the parts injected with fluorine, and nitriding the exposed surface of the oxide to form oxynitride or a nitride film on the exposed surface of the oxide. The example is illustrative using both a growth retardant and a growth promoter in the same location. In the example, the growth promoter is oxygen ions. There is nothing in this reference that discloses injecting fluorine in addition to injecting oxygen ions.

Accordingly, the reference does not disclose a process that also forms a nitride or oxynitride film on the surface of the oxide, after having injected the substrate with fluorine and oxidizing the parts having fluorine injected therein. Indeed, since one of the purposes of the process in HOULIHAN et al. is to reduce the number of steps, one of skill in the art would not find it obvious to also inject fluorine when using the

combination of nitrogen and oxygen ions. It is believed that claims 1-2 avoid the rejection under §102.

Claims 4-5 were rejected as unpatentable over HOULIHAN et al. in view of the APA, claims 3 and 6 were rejected as unpatentable over HOULIHAN et al. in view of the APA and RODDER et al. 6,251,761, and claims 7-9 were rejected as unpatentable over HOULIHAN et al. in view of the APA, RODDER and DEBUSK et al. 6,140,187. Reconsideration and withdrawal of the rejections are respectfully requested.

It is not believed that the further references, in combination with HOULIHAN et al., motivate one of skill in the art to form a nitride or oxynitride film on the surface of the oxide, after having injected the substrate with fluorine and oxidizing the parts having fluorine injected therein. For example, RODDER et al. suggest adding a layer of nitride 107 between a high-K dielectric 108 and a polysilicon or metal gate electrode 110 for the purpose of preventing the formation of silicon dioxide (column 3, lines 3-13). The gate oxide in HOULIHAN et al. <u>is</u> silicon dioxide (recall that the growth retardant and promoter in HOULIHAN et al. are for altering growth of oxide in unoxidized silicon, column 2, lines 38-42). There is no need to add a nitride layer to prevent growth of silicon dioxide when the layer is already silicon dioxide. Further, the layer from which the silicon dioxide is to be barred is the high-

K dielectric (adding silicon dioxide would reduce the effective K of the layer). Since the gate oxide in HOULIHAN et al. is silicon dioxide, the device therein does not have a high-K dielectric and thus there is no motivation to add the nitride layer from RODDER et al. to the device in HOULIHAN et al.

By way of further explanation, and in addition to the above, according to the present invention, the semiconductor substrate with fluorine injected therein is oxidized to form an oxide film. In the region where fluorine has been injected, the thickness of the oxide film is greater than the thickness of the oxide film in the other regions, since the oxidizing rate is increased by fluorine. Then, a surface of the oxide film is nitrided to form a gate insulating film containing nitrogen above the oxide film. The gate insulating film is effective in preventing an impurity of boron from being diffused. Therefore, the semiconductor device has high reliability and can operate at a high speed.

HOULIHAN et al. disclose that the gate insulating film having a different film thickness based on the injection of fluorine is formed. However, HOULIHAN et al. do not prevent the impurity from being diffused in the gate insulating film by nitriding the surface of the gate insulating film. More specifically, the present invention nitrides the surface of the gate insulating film after fluorine injection and thermal

oxidizing in order to prevent nitriding the interface between the gate insulating film and the semiconductor substrate, but HOULIHAN et al. have not disclosed this. HOULIHAN et al. only indicate that the purpose which injects nitrogen ion into the substrate is in order to decrease the oxidizing rate.

HOULIHAN et al. are distinguishable from the present invention in the process forming the gate insulating film. HOULIHAN et al. fail to disclose the process which nitrides the surface of the gate insulating film after fluorine injection and thermal oxidizing. HOULIHAN et al. disclose that a Si_xNO_y film (gate insulating film) is formed by heating after injection of nitrogen ion and oxygen ion. On the whole, this process has low oxidizing rate.

The diffusion of the impurity from an electrode is accelerated by fluorine injection. This is a well-known fact. Furthermore, nitrogen that is present at the interface between the oxide film and the semiconductor substrate brings about a defect referred to as an interface state and the property of a transistor is deteriorated as described in the specification. Thus, it is effective to nitride the surface of the gate insulating film without containing nitrogen at the interface state compared with SiON film of HOULIHAN et al.

In addition, the low oxidizing rate by nitrogen is mainly produced according to the effect which controls the

oxidization kind diffusion at the interface. Thus, SiON film of HOULIHAN et al. has a tendency to distribute its composition uniformly in the thickness direction or contrary to the present invention.

In view of the foregoing remarks, it is believed that the present application is in condition for allowance. Reconsideration and allowance are respectfully requested.

The Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 25-0120 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17.

Respectfully submitted,

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